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THE OCCURRENCE OF *ACICARPHA TRIBULOIDES* (CALYCERACEAE) IN EASTERN NORTH AMERICA

MELANIE L. DEVORE

ABSTRACT

Acicarpha tribuloides Juss. (Calyceraceae) has a natural distribution in southern Brazil, Uruguay, Paraguay, and northeastern-central Argentina. This species has also been collected in the United States, and Small (1933) reported it as being naturalized in northern Florida. Recent herbarium studies reveal that *Acicarpha tribuloides* occurred as a ballast plant in Pennsylvania, New Jersey, Alabama and Florida. Small's account was based on two specimens collected by Curtiss in 1885; no specimens of *Acicarpha tribuloides* collected after 1888 are known. *Acicarpha tribuloides* appears to be a well adapted weed in South America based on its abundance, multiple adaptations for dispersal, and on its ability to invade disturbed habitats and cultivated fields. This species may have failed to become naturalized in the United States due to: (1) climatic and edaphic barriers; (2) inability to compete with native and naturalized species; (3) low reproductive capacity.

Key Words: *Acicarpha tribuloides*, ballast plants, Calyceraceae, distribution, United States

INTRODUCTION

Acicarpha tribuloides Juss. (Figure 1) is one of five species of the South American genus *Acicarpha,* and occurs in Southern Brazil, Uruguay, Paraguay, Bolivia, Peru, and northeastern-central Argentina (Figure 2). The epithet "tribuloides" no doubt refers to the five persistent, spine-like calyx lobes protruding from the center of each achene, much in the same fashion as the genus *Tribulus* (Zygophyllaceae). Both *Acicarpha* and *Tribulus* exhibit fruits which in shape resemble a Roman tribulus (a device once used to impede calvary).

The first known specimens of *Acicarpha tribuloides* from the United States were collected sometime between 1867 and 1876 (Burk, 1877; Table 1). Additional specimens from the Eastern United States were collected between 1885 and 1888. Small (1933) reported the species from northern Florida, and Shetler and Skog (1978) listed *A. tribuloides* as an introduced annual. These reports provided a stimulus to investigate the distributional history and current status of *Acicarpha tribuloides* in the United States.

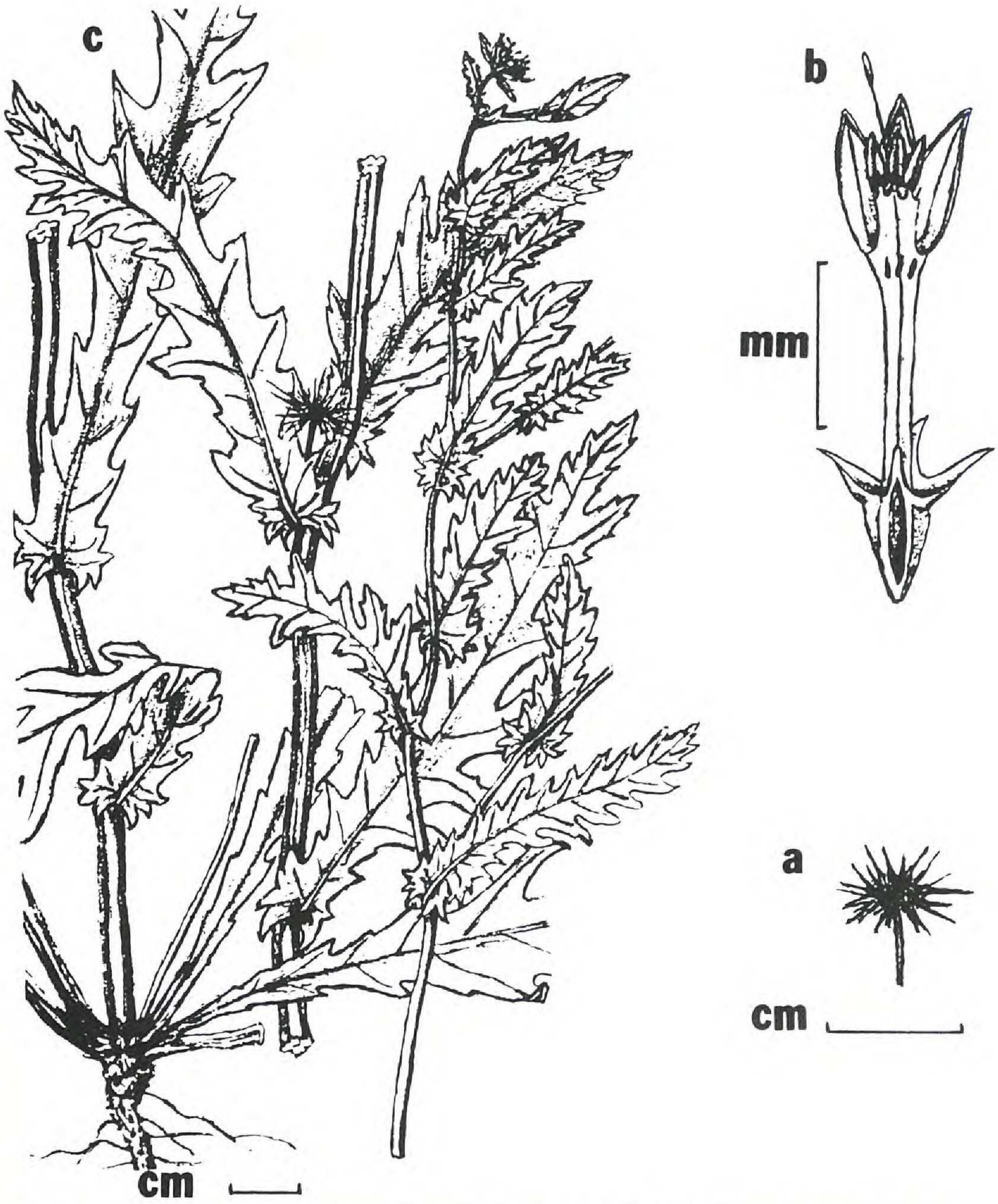

Figure 1. *Acicarpha tribuloides* Juss. **a,** capitulum; **b,** flower; **c,** habit. From Miers (1860: Plate 51).

NATURAL HABITAT AND MEANS OF DISPERSAL

Cabrera and Zardini (1978) noted that *Acicarpha tribuloides* commonly inhabits grasslands of deltas, river banks, and sandy ravines, and is an invader of cultivated fields. Flowers are borne in capitula (0.3–0.8 cm in diameter) attached to slight peduncles. At maturity, the calyx lobes of the peripheral achenes (central flowers are female-sterile) persist, and are adnate to the achene.

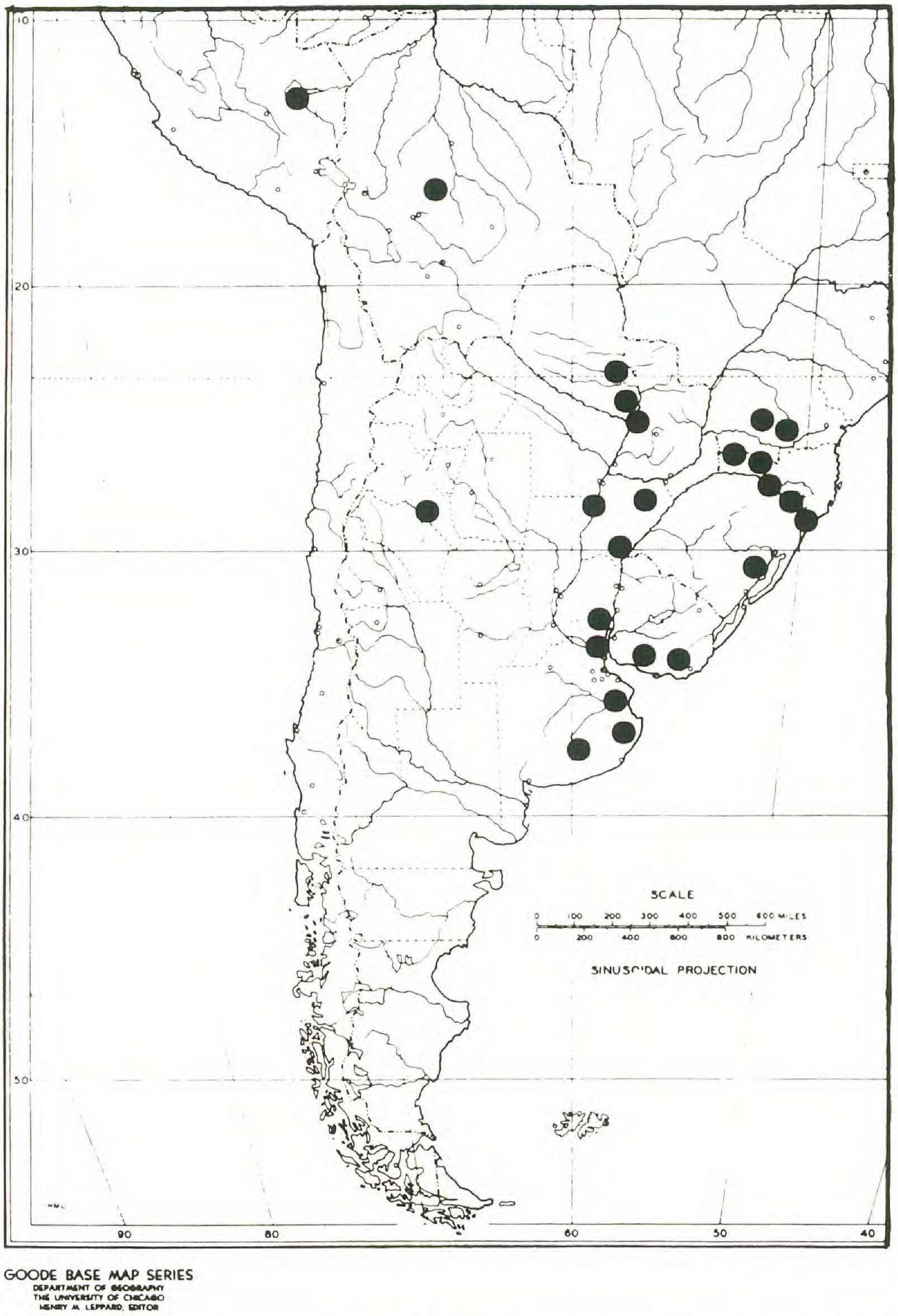

Figure 2. Map showing the natural distribution of *Acicarpha tribuloides* Juss. in southern South America.

Table 1. Collections of *Acicarpha tribuloides* Juss. from the eastern United States.

Collection Site	Collector*	Number of Speci-mens	Year	Location of Voucher Specimens
Philadelphia, PA	Burk	3	1867–75	F (310981, 319640), GH
Camden, NJ	Parker	1	1887	NY
North Carolina	McCarthy	2	1888	US (42101, 53061)
South Carolina	McCarthy	1	1888	GH
Walton County, FL	Curtiss	1	1885	GH
Pensacola, FL	Curtiss	1	1885	GH
Mobile, AL	Mohr	1	1888	US (53144)

* No collection numbers are recorded for these voucher specimens.

The achenes and receptacle fuse together and form an ovate, rigid, spiny, disseminule that detaches from the spindly peduncle (Figure 1).

Ridley (1930) hypothesized that plants with adherent calyces are almost certainly dispersed by wandering mammals. The ripened capitula of *Acicarpha tribuloides* may break off and become attached to a passing animal. Since the species is common along river banks, the spiny capitula may be transported by animals using these sites as watering places. Disseminules may also be wind-blown. Annual herbs inhabiting deserts, steppes, or praires often are dispersed when their inflorescenses become detached and are blown across open areas (Ridley, 1930). Morphologically, the detached capitula of *Acicarpha* could easily be tumbled across a sandy deltaic plain or river bank by wind.

Many specimens of *Acicarpha tribuloides* examined have been collected from river banks or ravines. In all likelihood, capitula are transported downstream and deposited on sandy river banks and bars. Species of *Acicarpha* appear to be well adapted weeds in South America based on their abundance, multiple adaptations for dispersal, and their ability to invade disturbed habitats and cultivated fields.

SITES OF INTRODUCTION IN THE UNITED STATES

The earliest known occurrence of *Acicarpha tribuloides* in the United States is near the Philadelphia area in 1867 (Table 1).

Burk collected plants from a ballast dump at Kaighn's Point which he identified as *Calycera balsamatifolia* (Burk, 1877). Careful examination of Burk's collections reveals that all three specimens are *A. tribuloides.*

Two specimens of *Acicarpha tribuloides* collected in the late 1880's from ballast sites in Camden, New Jersey, and Mobile, Alabama serve as evidence of later introductions of the species. Other specimens from North Carolina (1888) and Walton County, Florida (1885), lack label information regarding the specific locality (Figure 3).

MEANS OF INTRODUCTION

Ridley (1930) described six ways plants can be introduced: (1) as impurities with cereals, vegetables, and bird seeds; (2) as attachments to fleeces and hides of domesticated animals; (3) in animal fodder; (4) in packing materials; (5) as escapes from cultivation; and (6) in ships' ballast and exported soil. During the late 1880's ballast disposal was a common means by which alien plants were introduced. Ships usually took sand and gravel from a near-shore area at the beginning of a voyage, and discharged it at the port of destination. This practice continued until the early 20th century when water became the material used to weight ships. Burk (1877) noted that "improvements" made by the Pennsylvania Railroad and the American Steamship Company increased the number of vessels entering Philadelphia to export produce and merchandise. Marshland surrounding the harbor was covered with mud and sand dredgings and ballast was constantly added. Brown (1879) watched vessels dumping ballast day and night on Gowanus Creek in New York City. Late 19th century botanists not only observed ballast dumpings, but also made careful observations of the plants growing in the sites and traced their origins.

A large portion of ballast dumped in Philadelphia was oolite or chalk, materials indigenous to the British Coast. Many plants reported from the Kaighn's Point site were native to the British Isles. Others were South American or Southern European in origin, and such plants captured the imagination of Burk "either from their rarity or the place of nativity." The circumstances possibly responsible for the introduction of *Acicarpha tribuloides* are intriguing.

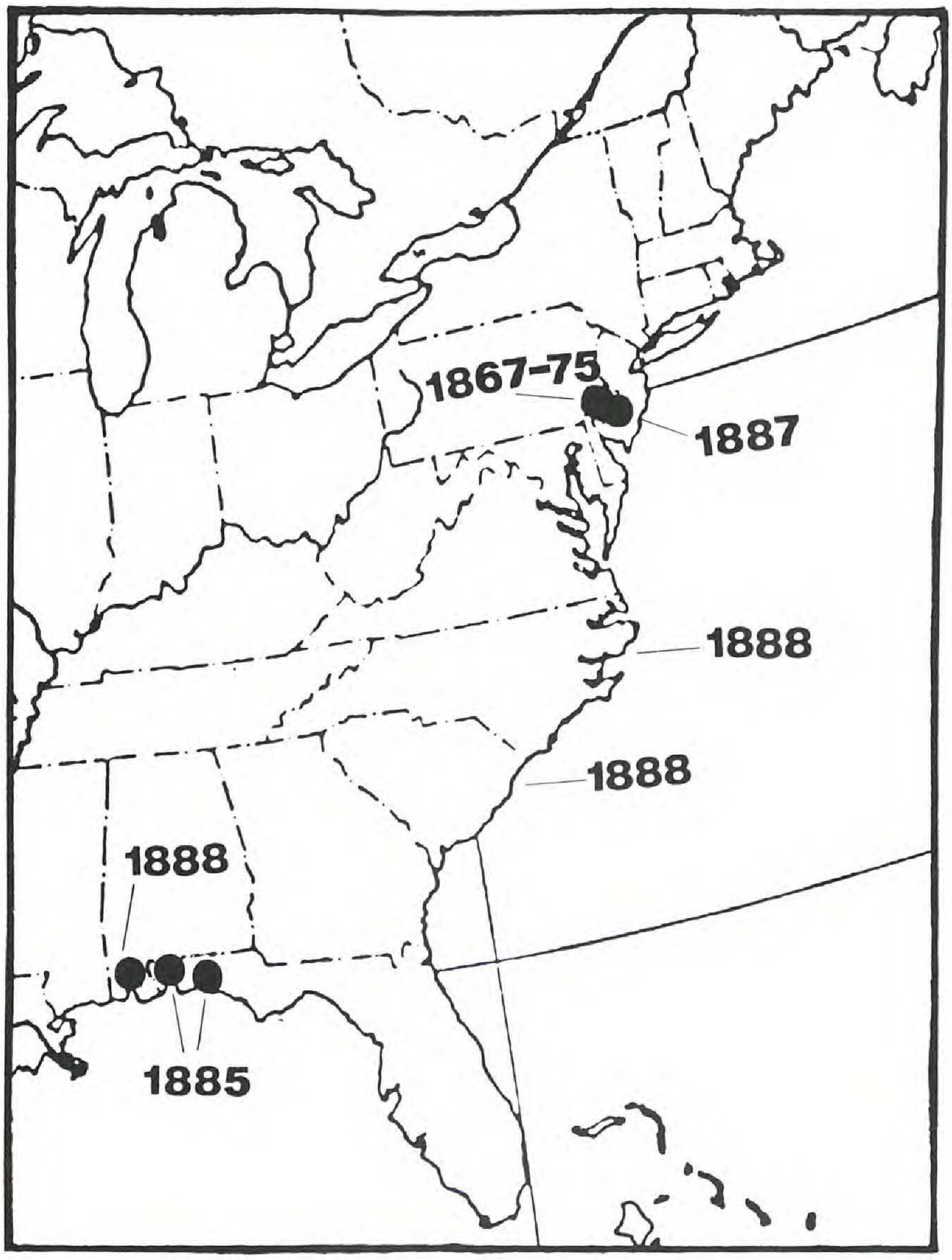

Figure 3. Sites of introduction of *Acicarpha tribuloides* Juss. in eastern North America.

On 26 December 1864 the Paraguayan dictator Francisco Salano Lopez invaded Brazil. Brazil formed a coalition with Argentina and Uruguay against Paraguay that lasted until the Brazilian lancers killed Lopez in the mid-1870's (Mooney, 1981). During the beginning of the Paraguay-Brazil conflict, the United States and the Confederacy were engaged in the Civil War. When defeat was inevitable, some Confederates formed colonization societies to promote emigration from North America. One popular choice of a new rebel homeland was Brazil, a country glamorized in books Southerners read before the war (Harter, 1985). Some colonists

failed to adapt to Brazil and were returned to the United States by vessels belonging to the Brazilian Squadron. Such ships as the *Kansas, Portsmouth,* and *Quinnebaug* protected United States citizens and economic interests during the Paraguay-Brazil War (Harter, 1985). Two ships belonging to this war squadron commonly traveled in the region of South America where *Acicarpha tribuloides* occurs naturally.

The *Wasp* was a small iron-hulled sidewheel steamer that joined the Brazilian Squadron after she was repaired in Philadelphia in 1867. She cruised the Plata and Uruguay Rivers during the war and remained in Uruguay after the war transporting diplomats and " guarding American interests." A second vessel, the *Juaniata,* patrolled the coast of Brazil as far south as Buenos Aires. In 1867 this steam sloop-of-war returned to Philadelphia and docked with monitors and ironclads in the Old Navy Shipyard (Coletta and Bauer, 1985; Mooney, 1981). The fact that Burk collected *Acicarpha tribuloides* in a Philadelphia ballast dump between 1867 and 1876 suggests that the plant may have been introduced via a naval vessel.

The circumstances responsible for later introductions of *Acicarpha tribuloides* are very sketchy. One possible means of introduction may have been by ships transporting farm equipment. The Argentinian economy boomed during the 1880's as a result of wheat cultivation. Lands previously utilized as sheep and cattle range lands were allocated for wheat. A great need for quality farm equipment resulted in strong trade relationships between the United States and Argentina and an increase in shipping (Koebel, 1912; Ross and McGann, 1982; Williams, 1975).

CURRENT STATUS

No specimens of *Acicarpha tribuloides* collected after 1888 are known. Burk (1877) observed a great variety of ballast plants, most of which survived a single growing season. Futhermore, herbarium studies reveal that Small's account was based on two specimens collected by Curtiss in 1885 (Table 1). Dr. Robert Godfrey (pers. comm.) has never discovered a population of *A. tribuloides* in his 35 years of botanizing in northern Florida. It appears that this species never became naturalized in the United States.

Some taxa have become naturalized after being introduced in ships' ballast. *Apium leptophyllum* (Apiaceae), native to Florida, Texas, and South America, became naturalized in Europe, West Africa, China, Japan, Australia, New Zealand and Polynesia. *Cakile maritima* (Brassicaceae), *Glaucium leuteum* (Papaveraceae), and *Plantago coronopus* (Plantaginaceae) were probably introduced to Southern Australia in ballast (Ridley, 1930). It is surprising that *Acicarpha tribuloides* never became established in Alabama or Florida. The species appears to be an abundant weed in regions of South America that are physiographically similar to southeastern United States.

Acicarpha tribuloides probably failed to become naturalized for a number of reasons. Any plant native to South America is likely to encounter some climatic and edaphic barriers to establishment. Seedlings are especially affected by these two factors since they lack the tolerance and vigor of a mature plant (Smith, 1978). If the seedling survives it is forced to compete with native and naturalized individuals. Ross and Harper (1972) suggested that an individual's ability to capture resources is restricted by the number and proximity of neighboring plants. Even if the founder is capable of scattering seed or reproducing vegetatively, the resulting population may be small and vulnerable due to low reproductive capacity and slow population growth (Smith, 1978). A small population of *A. tribuloides* growing in a constantly disturbed ballast dump site would be an excellent candidate for eradication.

Acicarpha tribuloides, as well as other members of Calyceraceae, possess capitula. The family bears a striking morphological resemblance to Asteraceae. The aggregation of flowers into a capitulum is believed to be the result of selection acting on the flowering phase of the plant. During the fruiting phase, the capitulum is vulnerable to herbivory (Burtt, 1978). To date, the only secondary compounds known to exist in Calyceraceae are monoterpenoid cyclopentanoid lactones called iridoids (Jensen et al., 1975). Cronquist (1988) speculates that the lack of diversification in Calyceraceae is not due to floral or vegetative morphology, but to limited chemical defenses that have evolved in the family. Cronquist's theory will be tested in the future when more is known about the biology and secondary compounds in the Calyceraceae. Currently, no members of the Calyceraceae oc-

cur as weeds outside South America, even though the family includes such weedy species as *Boopis gracilis* Phil., *Boopis anthemoides* Juss., and *Acicarpha tribuloides*.

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LITERATURE CITED

Brown, A. 1879. Ballast plants in New York City and its vicinity. Bull. Torrey Bot. Club. 6: 353–360.

Burk, I. 1877. Plants recently collected on ship's ballast in the neighborhood of Philadelphia. Proc. Acad. Nat. Sci. Philadelphia. 29: 105–109.

Burtt, B. L. 1978. Aspects of diversification in the capitulum, pp. 41–59. *In:* V. H. Heywood, J. B. Harborne and B. L. Turner, Eds., The Biology and Chemistry of the Compositae. Academic Press, London.

Cabrera, A. L. and E. M. Zardini, 1978. Manual de la Flora de los Alrededores de Buenos Aires. Editorial Acme S. A. C. I., Buenos Aires.

Coletta, P. E. and K. J. Bauer. 1985. United States Navy and Marine Corps Bases, Domestic. Greenwood Press, Westport, CT.

Cronquist. A. 1988. The Evolution and Classification of Flowering Plants, 2nd ed. New York Botanical Garden, Bronx, NY.

Harter, E. C. 1985. The Lost Colony of the Confederacy. University Press of Mississippi, University, MS.

Jensen, S. R., B. J. Nielsen and R. Dahlgren. 1975. Iridoid compounds, their occurrence and systematic importance in the angiosperms. Bot. Not. 128: 148–180.

Koebel, W. H. 1912. Argentina Past and Present. Kegan Paul, Trench, Trubner and Co. Ltd., London.

Miers, J. 1860. On Calyceraceae. Cont. Bot. 2: 1–42.

Mooney, J. L. 1981. Dictionary of American Naval Fighting Ships, Vol. VIII. Naval Historical Center, Department of the Navy, Washington, DC.

Ridley, H. N. 1930. The Dispersal of Plants Throughout the World. L. Reeve and Co., Ltd., Ashford, Kent.

Ross, M. A. and J. L. Harper. 1972. Occupation of biological space during seedling establishment. J. Ecol. 60: 77–88.

Ross, S. R. and T. F. McGann. 1982. Buenos Aires: 400 years. University of Texas Press, Austin, TX.

Shetler, S. G. and L. E. Skog. 1978. A provisional checklist of species for Flora North America. Fl. N. Amer. Rep. 84.

SMALL, J. K. 1933. Manual of the Southeastern Flora. (Facsimile) Hafner, New York, 1972.

SMITH, J. M. B. 1978. Dispersal and Establishment of Plants, pp. 207–223. *In:* D. Walker and J. C. Guppy, Eds., Biology and Quaternary Environments. Australian Academy of Science, Canberra City.

WILLIAMS, G. 1975. The Desert and the Dream. University of Wales Press, Cardiff.

DEPARTMENT OF PLANT SCIENCE
THE OHIO STATE UNIVERSITY
1735 NEIL AVENUE
COLUMBUS, OH 43210